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A FIRE SEASON SEVERITY INDEX FOR CALIFORNIA NATIONAL FORESTS

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When are the year to year variations in costs and accomplishments of a fire control organization due to variations in fire weather? When are the variations due to prevention and control action? To a combination of both? An index to the severity of fire weather by seasons can help answer these questions if the index separates the effects of weather on fires from the effects of prevention and control activities. This paper reports the results of an analysis made to determine such an index for California national forests.

Fire danger ratings compiled on the national forests were used as a measure of fire weather. The fire danger rating is determined daily on a scale of 0 to 100 for individual rating areas into which the national forests have been divided[1/]. The numerical rating is proportional to expected rates of forward spread of fire for observed conditions of wind velocity, temperature, humidity, and fuel moisture. The significance of a local fire danger observation to fire-control management is determined in part by comparing the observed daily rating with the long term mid-summer average for the rating area in which the observation is made. Making these daily comparisons is facilitated by application of a formula[1/] by which the degree of departure from mid-summer average danger is expressed as five qualitative danger classes: Low, medium, high, very high, and extreme.

1/ U. S. Forest Service. 1946. Fire Danger Rating Region 5. 9 pp. plus appendix.

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The study related the fire-danger rating to the number and size of fires, using data for 1,789 man-caused fires in 32 danger-rating areas in northern California, and 394 fires in 16 areas in southern California. The period of study was 1945 to 1952, and the data used were for the months of July, August, and September, when records were most complete and suppression forces near full strength.

Fire Danger and Number of Fires

Preliminary analysis showed that the number of fires was more closely related to the five danger classes than to the numerical rating. Accordingly, the average number of fires started per rating day[2/] was computed for each danger class in each of the rating areas. To eliminate the effect of size of rating area in the final summation, the ratio of number of fires per rating day for each class to that of the medium class was computed. These ratios showed that the number of fires increased rapidly with increase in fire danger (table 1). For northern California 1.47 times as many fires occurred on days of extreme fire danger as on days of medium danger; for southern California 1.65 times as many.

Table 1. --Effect of fire danger on number of man-caused fires

Fire danger class	Ratio of number of fires per day to number in medium class	
	Northern California	Southern California
Low	.57	.27
Medium	1.00	1.00
High	1.22	1.33
Very high	1.34	1.49
Extreme	1.47	1.65

Fire Danger and Size of Fires

Because the fire danger rating is a rate of spread index, the size a fire will attain may be expected to increase as the numerical danger rating increases. In order to determine the relation between size of fire and the danger rating, an analysis was made of the acreage burned at different levels of fire danger. From this analysis curves were developed which showed that the average size of fires increases very rapidly with increase in numerical danger rating, the rate of increase being the greatest in southern California (table 2).

2/ A rating day was considered as one day in each Fire Danger Rating area. Thus, for the northern California study area there would be 32 rating days for each day of the fire season.

Table 2. --Average size of fire for specified fire danger indices

Fire danger rating	Northern California	Southern California
	---Acres---	
10	20	9
20	97	57
30	248	173
40	482	379
50	806	696
60	1 228	1140
70	1 753	1741
80	2386	2505
90	3 131	3453
100	3993	4601

Fire Season Severity Index for Rating Areas

To determine the severity of fire weather for a season, it is essential that the weather for each day be evaluated in terms of the number of fires and burned acreage most probable for the day's level of fire danger. It is thus necessary to assume that a constant fire-starting potential exists, and that the number of fires starting and the size each attains depend upon the weather alone.

The data given in tables 1 and 2 indicate the relative chance, or frequency, of fire occurrence and the average size of each fire that does occur on any day of given fire danger. The product of appropriate values from these tables is a relative measure of the area most likely to burn for a rating day, and the sum of these daily products for a season provides a measure of the severity of the season. Comparison with other seasons can readily be made if the length of period considered in each year is held the same.

For the danger rating areas covered in this analysis, the seasonal totals of probable acreage burned were too large to make the amount of variation between seasons readily apparent. To overcome this difficulty, the seasonal total for each area was divided by the average for the period of record. The resulting ratio was termed the "severity index" for the season (table 3).

There are wide differences in the severity indices both in magnitude and trend by seasons. This is sometimes true even for adjacent areas. Areas with similar severity tend to be grouped; but there appears to be no consistent relation in severity between areas, and the grouping varies in different seasons. Separately or in combination latitude, longitude, altitude,

Table 3. --Fire season severity indices for fire danger rating areas in California, 1945-1952

NORTHERN CALIFORNIA

Rating area	1945	1946	1947	1948	1949	1950	1951	1952
Lassen								
1	----	1.00	.37	.79	1.08	1.42	1.34	1.15
2	----	1.00	.93	.99	.74	1.25	1.08	1.13
3	----	.95	1.23	.75	1.09	.75	1.22	.48
4	----	1.05	1.05	.80	1.05	.98	1.09	.71
Mendocino								
1	1.35	.51	.87	.84	.92	1.32	1.19	.89
2	1.47	.91	.91	.71	.86	1.07	1.07	.96
3	1.37	.76	.76	.71	.83	1.29	1.30	1.27
5	.93	.78	1.00	.67	.62	1.47	1.53	1.63
Modoc								
1	----	----	----	.92	1.03	.76	1.28	1.02
2	----	----	----	.82	1.03	.70	1.40	.59
3	----	----	----	.92	1.03	.91	1.13	.94
4	----	----	----	.89	1.06	.93	1.10	.95
Plumas								
1	1.29	1.09	1.01	.78	.89	.94	1.00	.88
2	1.08	1.10	.87	.47	1.12	1.20	1.16	.62
3	.85	1.05	1.22	1.04	1.00	.68	1.16	.59
Sequoia								
1	.93	.69	.83	1.23	1.23	1.12	.97	.66
2	.76	.80	1.18	1.28	.74	1.12	1.11	.77
4	----	.55	1.03	.81	1.00	1.17	1.44	.73
5	----	2.21	1.00	.69	.62	.72	.38	.83
Shasta								
1	.90	.95	1.01	.75	1.15	1.13	1.10	----
2	1.24	1.11	.77	.90	1.05	.96	1.00	----
3A	1.27	.77	.76	.64	1.07	1.25	1.23	----
4	1.49	1.18	.73	.76	1.08	.77	.99	----
5	----	1.00	.92	.95	1.13	.83	1.17	----
6	----	1.41	1.10	1.01	.89	.58	1.03	----
7	1.06	.84	.61	.69	.70	1.08	2.02	----

Table 3. --(continued)

NORTHERN CALIFORNIA

Rating area	1945	1946	1947	1948	1949	1950	1951	1952
Stanislaus								
1	.71	.99	1.10	.98	1.04	1.14	1.03	.50
2	.74	1.45	.61	.95	.75	1.45	1.06	.34
Tahoe								
1	1.43	1.07	.78	.62	.89	1.07	1.14	.90
2	.93	1.28	1.39	.70	.82	.83	1.06	.50
3	.66	1.45	1.31	.64	1.24	.50	1.27	.44

SOUTHERN CALIFORNIA

Rating area	1945	1946	1947	1948	1949	1950	1951	1952
Los Padres								
1	.81	.88	.98	1.19	.85	.94	1.35	.79
2	1.29	.61	.82	1.21	.97	1.20	.89	.81
3	1.93	.75	.81	1.29	.67	.77	.78	.63
4	1.31	.81	.81	----	.89	1.01	1.16	.63
4A	1.97	.69	1.65	1.43	.40	.53	.34	.55
5	----	----	.32	1.04	.89	1.29	1.45	.58
6	1.41	.63	.85	1.19	.99	.58	.94	.69
7	1.92	.91	1.12	.89	.82	.72	.63	.79
8	1.01	.61	.17	1.06	.89	1.34	1.91	1.25
9	1.49	1.04	.61	1.16	1.00	.64	1.07	.81
San Bernardino								
1	1.14	.73	.88	2.01	.74	.70	.81	.79
2	.95	.93	1.08	1.39	.79	.99	.87	.71
3	1.46	.74	.87	1.10	.84	.95	1.04	.87
4	1.51	.49	.90	1.46	.88	.80	.96	.94
5	1.67	.45	.94	1.56	.64	.94	.80	1.61
7	.87	.57	.94	1.74	1.07	.82	.99	.75

or general aspect appear to control the grouping for each season. For example, in 1945 the severity of fire season for rating areas in the southern Sierra Nevada and east slope of the Sierra Nevada tended to be low. Low elevations in the coastal regions and the northern Sierra Nevada had high severity that year. In 1947 the east slope of the Sierra Nevada had severe conditions, but low to moderate severity occurred in the coastal regions and in southern California. In 1948 most of northern California had low severity, while in southern California the severity was high.

The reason for these irregularities is not apparent from the data available in this study. It is probable that the tendency of the areas to vary in their grouping from year to year is the result of large-scale climatic variations.

Severity Index for Combined Areas

The use of the data in table 1 for computing severity indices assumes an equal number of fires starting in all areas. Indices computed on this assumption are valid for comparisons of seasons for any given area or for comparing relative trends between areas. Average fire occurrence per rating day, however, varies widely among the rating areas. The indices in table 3 thus cannot be added directly to obtain an index for combined areas, since a change in the severity index for an area of high fire occurrence has a relatively larger effect on the probable number of fires and acreage burned than does the same change in severity index for an area of low fire occurrence.

To provide an overall severity index the indices in table 3 were weighted by the fire occurrence per rating day for the area. The averages of the weighted indices were then obtained for each season to give a severity index for the combined areas (table 4). For northern California 1945 was the most severe year for the period; the probable burned acreage was 1.17 times the average. In southern California a severity index of 1.42 indicated that 1948 was the most severe year.

Table 4. --Relative severity of fire seasons for California national forests, 1945-1952

Year	Northern California	Southern California
1945	1.17	1.38
1946	1.06	.72
1947	.98	.89
1948	.77	1.42
1949	.96	.85
1950	.96	.88
1951	1.09	.96
1952	.76	.87

In making local applications of this study, it should be remembered
hat the relation between size of fire and danger rating illustrated in table 2
s based on the average size of fire. Because the data included many very
mall fires, the potential fire size for any given danger rating is much
reater than the average shown in the table. Table 2 shows, then, that as
he danger increases, more and more fires that start tend to become large
ires. Furthermore, the number of fires starting also becomes greater,
s shown in table 1. The potential fire load thus becomes acute with increas-
ng rapidity as the danger increases. This further emphasizes both the need
or greater preventive and preparedness effort when the danger rises and the
eed for all-out attack on fires that do start.